Experiential Learning Integrated Inquiry in Science Education to Promoting Scientific Literacy: A Conceptual Model

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Abstract. Without experiencing things, learning science will not take place. Since it incorporates real-world situations, this learning will produce relevant instruction. The experiential learning model stresses first-hand experience. However, it has flaws in concrete experience and active experimentation stages. Focusing on students' experiences and in-depth experimentation activities is necessary to address these deficiencies. This paper combines the inquiry-based and experiential learning models to strengthen its shortcomings. Inquiry-based learning makes it possible to practice thorough experimentation. The experiential and inquiry-based learning models should be integrated to generate active, experiential-based education. Through inquiry, learners will actively engage in investigation, observation, reflection, and conceptual comprehension. In other words, this integration will produce scientific literacy and critical learners who can solve challenges that arise in the real world.

Keywords: Experiential, Inquiry, Scientific literacy, Science learning

1 Introduction

In the twenty-first century, science and technology are advancing quickly in numerous areas of life, including education. The goal of education in the twenty-first century is to create human resources with the skills necessary to compete on a global scale and to comprehend science and technology. Everyone should be able to understand knowledge and possess learning and innovation skills, literacy skills, and life skills to deal with learning in the twenty-first century [1]. This is crucial so people can make informed judgments about handling challenges daily.

Students must have a solid understanding of scientific concepts, the interrelationships between science, technology, and society, and how to apply knowledge to solve problems in daily life. The development of a scientifically literate society is one of the objectives of science education [2]. According to Drake & Reid [3] scientific literacy is the knowledge and comprehension of scientific ideas, methods, and processes necessary to contribute to society and make informed decisions. To solve problems and make

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decisions, you must be able to apply scientific knowledge and skills based on empirical data that is relevant to everyday life [4]. This is achieved by practicing scientific literacy.

Scientific literacy development in the field is still primarily focused on cognitive skills [5]. Finding facts and ideas about the phenomena of everyday experience is difficult for students. Students still struggle with recognizing occurrences and applying scientific concepts to real-world issues. As a result, scientific education must focus on learning relevant to daily living and incorporating real-world experiences.

The development of cognitive abilities and scientific literacy is possible through the integration of concepts in daily life in a relevant science learning orientation, which will result in meaningful learning [6]. Students are encouraged to gather information about events and experiences from daily life and use investigative activities to uncover scientific facts and generate meaningful science learning. Therefore, science teaching should be developed and implemented using methods, strategies, and techniques that may accommodate contextual requirements.

Experiential Learning (EL) is a context-based learning theory emphasizing the importance of experience as a source of knowledge. Experiential learning emphasizes challenges and experiences while reflecting on the knowledge gained from those experiences [7]. Experience serves as the learning medium in experiential learning (EL). This model's concrete experience stage did not emphasize contextual information and active experiments, which have not maximized activities to explore existing experiences [8], [9] are two areas where it falls lacking. A learning paradigm that strengthens EL is required to address these issues, and inquiry-based learning (IBL) is one such model. Students will engage in investigations using experiences or events in their environment. This will be consistent with the nature of science learning and assist in strengthening contextual information and active experiments. Through investigative activities, students can improve their scientific literacy and skills [10], [11].

According to the above study, an integrated learning model that combines experiential learning and inquiry-based learning is required. This article will discuss models that make it easier for researchers to investigate theories based on student observations and conduct scientific investigations. Emphasizing an inquiry method to provide events and experiences around them as learning materials, analyzing these phenomena, and exploring scientific science seeks to generate students who can learn science in line with their nature.

2 Method

The method used was qualitative analysis, and the primary source was an analysis of the literature on inquiry-based learning and experiential learning models and their connection to the growth of students' scientific literacy. The learning paradigm that was researched was an inquiry-based and experiential learning model. Based on this, the ability of experiential learning integrated inquiry models to strengthen students' scientific literacy in science learning is next explored.

3 Results and Discussion

The concepts, characteristics, and syntax of the phases of learning that contain the activities carried out in the model are discovered from the findings of a literature review on the experiential learning model and the inquiry-based learning model. Furthermore, it analyses the elements of scientific literacy and the definition of scientific literacy. The last study discusses how integrating experiential learning and inquiry could enhance students' scientific literacy.

The learning model, in the opinion of Joyce and Weil [12], is a strategy used to build the curriculum, construct learning resources, and provide activity instructions for direct learning in the classroom or other learning environments. Kilbane & Milman [13] suggested that the learning model is a unique approach that supports learning process activities intended to achieve learning outcomes through carefully structured activities. More specifically, in the words of Eggen & Kaucak [14] a learning model is a framework for achieving learning objectives that captures the big picture of the learning process. According to this point of view, the learning model may be defined as a collection of learning plans or strategies that are methodically created to accomplish specific goals and outline the general procedures of learning activities.

3.1 Experiential Learning (EL) Model

According to Kolb's theory, knowledge is created via the transformation of experience; this is how the experiential learning model works [15]. The interaction between doing and thinking is a part of learning from experience. The objectives of Vygotsky's social constructivist learning theory are consistent with the creation of the experiential learning model, claim Kolb & Kolb [16]. A person will learn far more effectively if they actively participate in the learning process. Vygotsky asserts that individuals underlie mathematical logic and scientific knowledge development. Experience is the only way knowledge is built and cannot occur in nothingness. By giving students the chance to grow and acquire information through their experiences, this theory highlights the importance of a learning environment [17]. Experience will give a youngster a foundation for contemplation, observation, comprehending, and analyzing knowledge.

Experiential learning is a type of learning that involves both the acquisition of grasping experiences and the change of transforming experiences. Experience acquisition can take place directly, indirectly, or via the senses. Reflection and student involvement in scientific pursuits are key components of transformative experiences.

The Experiential Learning model describes two information acquisition models, concrete experience and abstract conceptualization, and two experience transformation models, reflective observation and active experimentation. Kolb was the first to identify the stages of experiential learning, and he distinguished four of them: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Collins & Redden, 2021). The essence of each step is as follows in more detail:

- Concrete experience: Learning from specific experiences. Being sensitive to situations.
- Reflective observation: Consider the environment from different perspectives before making decisions.

- Abstract conceptualization: Logical analysis of ideas and acting according to the understanding of a situation.
- Active experimentation: the capacity to engage in several activities with people and take appropriate action in response to circumstances.

The Experiential Learning paradigm of science education combines active experimentation, reflective observation, concrete experiences, and abstract concepts to help students develop their scientific literacy.

According to Kolb, the two guiding principles of the experiential learning syntax are the model of experience transformation utilized as a development reference at each level and the acquisition model of transformation: 1) Setting up specific experiences for pupils to partake in; 2) arranging analysis and processing experiences; 3) generalizing; and 4) setting up applications and positive testing [18]. Smith, meanwhile, used experiential learning in his studies, which included the stages of concrete experience, observation and reflection, the creation of abstract notions, and testing in novel circumstances. By integrating collaborative work with the stages of experiential learning—concrete experience, observation, reflection on the experience, and creation of abstract concepts—Alexios Brailas redeveloped Smith's research findings [8].

By identifying flaws in the concrete experience and active experiment stages, Thomas Howard Morris undertook a systematic review to modify the stages described by David Kolb [9]. Morris cites contextually rich concrete experience, critical reflective observation, contextual-specific abstract conceptualization, and pragmatic active experimentation as the foundations of his changes. Makoto Matsuo and Masaki Nagata conducted a second study to update David Kolb's stages of experiential learning. According to their findings, these stages include (1) expected and unexpected experiences, (2) the management of emotions, (3) reflective analysis, (4) abstract conceptualization, (5) unlearning, and (6) active experimentation [19]. In Table 1, the stages of experience learning are summarized.

Table 1. Syntax of experiential learning from an expert

Kolb, 1984 [20]	**Smith, 2010** [21]	**Brailas et al, 2017** [8]
1. concrete experience 2. reflective observation 3. abstract conceptualization 4. active experimentation	1. concrete experience 2. observation and reflection 3. the formation of abstract concepts 4. testing in new situations	1. concrete experience 2. observation 3. reflection on the experience 4. formation of abstract concepts
Morris, 2020 [9]	**Tong et al, 2020** [18]	**Matsuo & Nagata, 2020** [19]
1. contextually rich concrete experience 2. critical reflective observation 3. contextual-specific abstract conceptualization 4. pragmatic active experimentation	1. Organizing for students to participate in specific experiences. 2. Organizing analysis and processing experience 3. Generalizing 4. Applying and positive testing	1. expected and unexpected experiences 2. the management of emotions 3. reflective analysis 4. abstract conceptualization 5. unlearning 6. active experimentation

A synthesis of the syntax of experiential learning in this paper, namely contextually concrete experiences, critical reflective observation, abstract conceptualization, and active experimentation.

3.2 Inquiry Based Learning Model

The term “inquiry” has been used to describe three distinct categories of activities in the context of scientific education: what scientists perform, how students learn, and the pedagogical method employed by teachers [22]. According to Keselman [23] Inquiry-based learning (IBL) is a method students use to generate new knowledge by conducting investigations, much like professional scientists. According to another definition, Inquiry-Based Learning (IBL) is a method for students to learn new information by establishing causal links, resolving issues, and testing hypotheses through experiments, observations, or investigations that do not involve empirical testing [24].

The purpose of IBL is to provide evidence and justifications for natural [25]. Another point made is how the inquiry process helps students build higher-order thinking skills and a firmer grasp of how to apply scientific ideas to real-world situations [26]. Additionally, inquiry-based learning can give students the chance to engage in crucial epistemic procedures for the growth of scientific literacy [11]Cara Gormally et al. expressed a similar idea—that students' science literacy skills can be fully developed through inquiry. [25]. IBL, or inquiry-based learning, is a teaching strategy that encourages students to research to find solutions to challenges in their daily lives.

When it comes to science learning, Wenning introduced the levels of inquiry (LOI), which include discovery learning, interactive demonstration, inquiry lesson, inquiry laboratory, fundamental word application and hypothetical Inquiry [27]. The syntax at the Inquiry level is the same, but the levels are different at each level depending on the intellectual ability of the students and the controller. For example, 1) Observation includes observing phenomena, identifying problems, and formulating problems; 2) Manipulation includes actions like expressing ideas, creating designs, and conducting investigations; 3) Generalization includes actions like building knowledge based on investigations; 4) Verification includes giving logical justifications and drawing conclusions; and 5) Application includes actions like applying the concepts learned to other real-world scenarios.

Meanwhile, Dewey [28] suggests inquiry-based learning includes (1) asking and defining questions or problems; (2) investigating, to answer questions, it is necessary to carry out investigative activities; (3) creating, students create new ideas beyond previous knowledge; (4) discussing, students discuss new ideas with others; and (5) reflecting, looking back at questions and conclusions or new thoughts obtained.

In addition, Pedaste et al. [24] conducted a literature study on 32 papers examining inquiry-based learning (IBL) processes or stages. There are five general stages of IBL, each with its sub-phases, according to the review undertaken by Pedaste et al. Five steps make up the main phase of inquiry-based learning: 1) Orientation, 2) Conceptualization (questioning and hypothesis generation), 3) Investigation (exploration/experimentation and data interpretation, 4) Conclusion, and 5) Discussion (communication and reflection).

3.3 Scientific Literacy

Inquiry-based learning can shape and develop students' capacity to comprehend fundamental ideas and concepts. Inquiry aids in the transfer of ideas to new learning settings and the growth of systematic, logical, and critical thinking skills [11], [29]. Scientific literacy can be developed through inquiry learning in addition to scientific abilities [10], [11]. Questioning that being objective, honest, and open as a scientific activity is the essence of science learning will motivate students to think and work on their initiative. This is supported by the design of 21st-century science education, which promotes scientific literacy to solve global issues and the ability to comprehend science through the discovery process [30]–[32].

The ability of citizens to decide on problems that arise in daily life is the emphasis of scientific literacy. As information and technology advance, it becomes increasingly necessary to recognize key skills and knowledge, such as communicating and collaborating with people, handling information, and comprehending the nature of knowledge. To prepare pupils for 21st-century society, scientific literacy requires developing their capacity for problem-solving daily. Some experts argue on the meaning of scientific literacy, which is summarized in Table 2.

Table 2. Definition of scientific literacy

Expert	**Definition**
Bybee, 2006 [33]	awareness of the key ideas, conventions, and methods of science so that scientifically literate people have access to scientific knowledge, can use that knowledge as citizens, and contribute to decision-making in technological and scientific societies
Tytler, 2007 [34]	Science literacy in the context of overarching science learning domains helps students communicate with others in local, national, and international communities and make responsible decisions.
Holbrook & Rannikmae, 2009 [35]	The ability to creatively use scientific knowledge and skills based on empirical evidence, especially those relevant to careers and daily life, to solve problems and make socio-scientific decisions.
Fives et al, 2015 [36]	ability to understand phenomena processes and engage meaningfully in scientific information in everyday life
OECD, 2015 [37]	The capacity to detect issues and generate conclusions based on data to comprehend and inform decisions regarding the natural environment and changes brought about by human activity.
PISA, 2019	the ability to use scientific knowledge and processes not only to understand the natural world but also to participate in decisions about it and changes made by human activity.

3.4 The Potential of Experiential Learning Integrated Inquiry Model to Empower Scientific Literacy

Constructivist learning theory serves as the foundation for the experiential learning model. Constructivism is a method of education that strongly emphasizes how students actively create their knowledge via interaction with their surroundings and life experiences. This theory provides the basis for the experiential learning model by highlighting the active role of learners in constructing their knowledge through direct experience, reflection, and interaction with the environment and others. This model promotes learner-centered learning, allowing them to create their understanding meaningfully and relevantly.

Furthermore, the inquiry model is also supported by constructivism theory. Constructivism strongly emphasizes how students actively create knowledge through contact with the outside world and personal experience. The inquiry paradigm encourages students to ask questions, investigate, and find their solutions using critical thinking. Through inquiry and research, learners play the role of knowledge builders and produce new understanding.

Inquiry and experiential learning are combined using the same learning theory's guiding principles to encourage active participation, knowledge construction, critical thinking, social interaction, and the development of in-depth understanding. Combining inquiry-based learning and experiential learning produces an innovative and successful learning strategy. This model is called the Experiential Learning Integrated Inquiry (ELLIn) Model. The conceptual design of the ELLIn Model is presented in Figure 1.

Several experts have defined scientific literacy, and it can be inferred from their definitions that scientific literacy is the capacity to use knowledge (science concepts) and science skills to address issues and reach conclusions regarding the natural world as a member of society. This capacity involves recognizing phenomena, assessing and planning investigations using scientific methods, scientifically interpreting data and evidence, and developing an attitude toward science.

The ELIIn Model will help learners gain knowledge of the science concepts underlying natural phenomena and experiences. They will learn to relate these concepts to real experiences and identify implications and applications in everyday situations. Learners will also be trained to understand and evaluate information related to science. They will gain the ability to gather, arrange, and understand facts and make decisions based on scientific evidence through the inquiry process. In the form of experiences, this instructs students on the scientific approach to investigate and comprehend natural occurrences. They will learn how to exercise critical thought and problem-solving abilities through the design of experiments, data collection, and hypothesis testing

In this ELLIn Model, students will experience learning that is contextual and relevant to everyday life. Thus, they will be trained in problem-solving based on real situations and community needs. Problem-solving is completed through inquiry activities that will train learners in scientific communication. They will learn to convey the results of research or experiments clearly and systematically, both orally and in writing. Through the stages in the ELLIn Model, learners will be trained to think critically and reflect on their experiences and understanding. This will help them to evaluate information, construct arguments, and find solutions based on valid evidence and data.

Therefore, the ELLIn Model's incorporation of experiential learning and inquiry will result in a more complete and learner-centered learning process. As a result, students will study more about science and develop excellent scientific literacy. This ability will be important in facing challenges and opportunities in an increasingly complex and globally connected world.

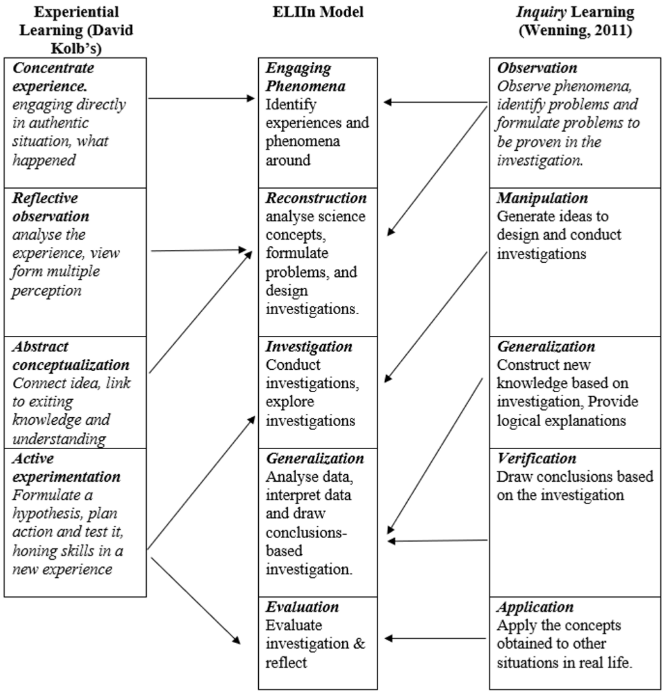

Fig. 1. The conceptual design of the ELLIn Model

4 Conclusion

It can be concluded that learning using the ELLIn Model integrates hands-on experience with inquiry and discovery. Learners experience concepts directly and are invited to conduct further investigations, collect data, analyze information, and make discoveries. Learning with the ELLIn Model has strong potential to improve students' scientific literacy. By providing opportunities for students to be actively involved in science exploration and inquiry through hands-on experience, this process can shape learners who are critical, skillful, and able to overcome scientific challenges in everyday life.

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